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**Unit 8, Part 3 Notes: Patterns of Natural Selection and Evolution**

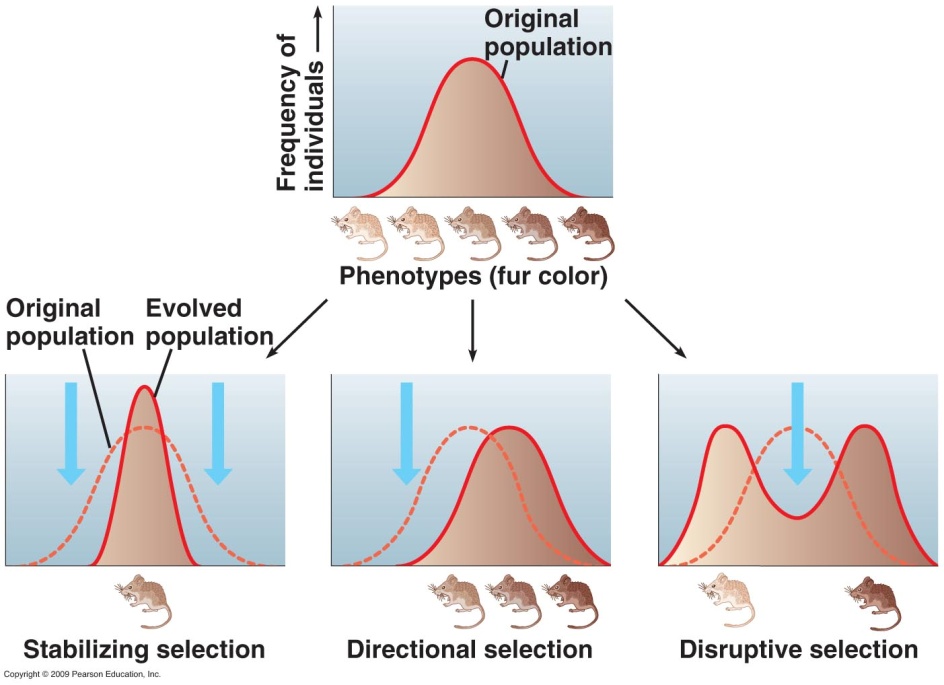
Pre-AP Biology, Mrs. Krouse

**1. What are the types of natural selection?**

1. We can define several types of natural selection based on how trait frequencies change in the population after selection takes place.
2. Three types of selection—stabilizing selection, directional selection, and disruptive selection—can occur when a trait has a range of possible **phenotypes**. For example, human height ranges from short to medium height to tall. Also, fur color in mice ranges from light to medium color to dark.
3. **Stabilizing selection** occurs when a selection pressure in the environment causes the medium or average form of a trait to become more common. In other words, the average form of the trait gives organisms in the population a higher **fitness.** These organisms are more likely to survive and reproduce than organisms with either extreme form of the trait. If stabilizing selection occurs on the trait of mouse fur color, then medium color fur will increase in frequency, whereas light and dark fur color will decrease in frequency.

*Remember: A* ***selection pressure*** *is a factor in the environment that causes evolution.* ***Evolution*** *is a change in gene and trait frequencies over time (several generations) in a population of organisms.*

1. Stabilizing selection is shown in the set of graphs given on the next page, which shows the original frequencies of the different mouse fur colors before stabilizing selection occurred as a dashed line. It also shows the frequencies of the different mouse fur colors after stabilizing selection occurred as a solid line.
2. **Directional selection** occurs when a selection pressure in the environment causes ONE extreme form of the trait to become more common. In other words, this extreme form of the trait gives organisms in the population a higher fitness. These organisms are more likely to survive and reproduce than organisms with other forms of the trait. If directional selection occurs on the trait of mouse fur color, then either light or dark fur color will increase in frequency (not both).
3. Like stabilizing selection, directional selection is shown in the set of graphs given on the next page. In this case, the environment **“selected for”** the trait of dark fur color and **“selected against”** the traits of light fur color and medium fur color. As a result, dark fur color (one extreme form of the trait) became more common after selection.
4. **Disruptive selection** occurs when a selection pressure in the environment causes BOTH extreme forms of the trait to become more common. In other words, both extreme forms of the trait give organisms in the population a higher fitness. These organisms are more likely to survive and reproduce than organisms with the average form of the trait. If disruptive selection occurs on the trait of mouse fur color, then both light and dark fur color will increase in frequency. Disruptive selection is also called **diversifying selection**.
5. Like stabilizing selection and directional selection, disruptive selection is shown in the set of graphs given on the next page. Notice that both light and dark fur color became more common after selection, while medium fur color became less common.



***Practice Question #1:*** For each scenario described below, identify whether it is an example of stabilizing selection, directional selection, or disruptive selection. Explain your choice. Then, explain how trait frequencies will change in the population over time as a result of this selection.

1. In this environment, birds with short and long feathers are better able to escape predators than birds with medium-length feathers

Type of selection and explanation:

How will trait frequencies change in this population over time?:

1. The environment becomes very windy and birds with long and short feathers have difficulty flying in these conditions. Birds with medium-length feathers are more likely to survive and reproduce.

Type of selection and explanation:

How will trait frequencies change in this population over time?:

1. Birds with shorter feathers are better able to fit into small spaces to access food.

Type of selection and explanation:

How will trait frequencies change in this population over time?:

1. Another type of natural selection is **sexual selection**. Sexual selection occurs when traits that make an organism more likely to reproduce become more common. This could happen as a result of…
2. Female choice: In many animal species, females choose males that display certain traits to mate with. For example, peahens (female) tend to choose peacocks (males) with long, brightly-colored feathers. They do this because feather length and bright coloration can be an indicator of the health of the male. Therefore, peahens choose mates that will be more likely to produce healthy offspring. As peacocks with the longest, brightest feathers are more likely to reproduce and pass their genes on to their offspring, these traits become more common among males in the population over several generations.

Among male peacocks, feather length is unlikely to continue to increase. Feathers that are any longer may make peacocks less likely to survive because they cannot escape from predators. If they cannot survive until reproductive age, then they will not pass their genes on to the next generation. As such, peacock feather length is a good example of the trade-off between a reproductive advantage and a survival disadvantage. This has resulted in feather length among peacocks stabilizing at a certain length that is beneficial for reproduction and not overly detrimental to survival.

In other species, females may also choose males that perform the best mating dances, have the best mating calls, etc.

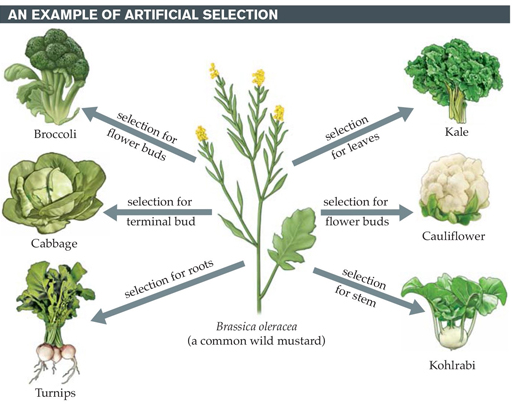
1. Male competition: In many animal species, males compete (fight) against each other for the chance to mate with females. Traits that make males more likely to win this competition will become more common over time in the population because males with these traits reproduce more.

For example, male elk use their antlers to spar (fight) one another when competing for females. Larger antlers make the males more likely to win these fights and reproduce with females. As such, larger antlers have become more common over time in the population.

1. The final type of selection we will discuss is **artificial selection**. Remember, in natural selection, the environment determines which traits make an organism more likely to survive and reproduce. In artificial selection, humans determine which traits make an organism more likely to survive and reproduce.

For example, humans have bred dogs with certain “desirable” traits to create generations of puppies win which these traits are more common. Among Great Danes, humans have selected the largest males and females to mate, which has resulted in large size becoming more common in this breed.

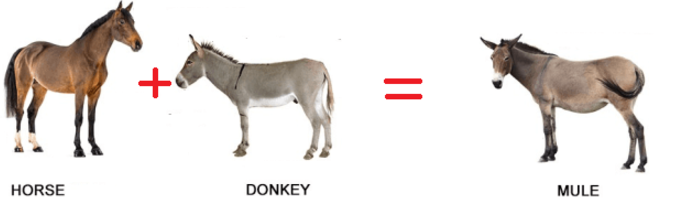
Humans have also selected plants with certain desirable traits (ex: higher vitamin content, better taste) to reproduce, resulting in the evolution of different types of vegetable from an ancestor species of wild mustard plant (see image below)



**2. How are new species created through evolution?**

1. There are several different methods that scientists use to define a species. Several methods are discussed below.
2. The **Morphological Species Concept** states that organisms with very similar body structures belong to the same species. This species concept is most helpful for fossilized species for whom we do not have information about reproductive habits.
3. The **Biological Species Concept** states that organisms that can mate in nature and produce viable, fertile offspring are members of the same species. **Viable** means the offspring must be able to survive. **Fertile** means the offspring must be able to reproduce. This species concept is most helpful for currently-living species for whom we can observe their reproductive habits. In this class, we will use the biological species concept.

For example, horses and donkeys are considered two separate species. They can mate and produce hybrid offspring, which are called mules. Mules are viable, but they are not fertile. They are sterile, which means they cannot reproduce. Because horses and donkeys cannot produce viable AND fertile offspring, they are considered two different species.



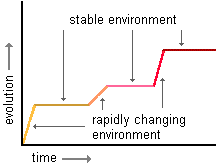
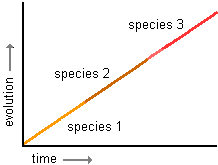
1. If two populations of a species evolve to be very different from one another (due to different environmental conditions), they may change so much that they are no longer able to mate in nature and produce viable, fertile offspring. At this point, we would say they have become two different species, a process called **speciation.**
2. Typically, speciation occurs when two populations of the same species become physically separated from one another (ex: by a river or mountain range). This is called **geographic isolation.** When this happens, the two populations are not able to **interbreed** (mate with one another), and may be exposed to different environmental conditions. As such, they may evolve to have different physical attributes, behaviors, etc.
3. The populations may, over time, evolve so that **reproductive barriers** form between them. Reproductive barriers are factors that prevent organisms from the two populations from mating with one another. For example, the populations may evolve to have different mating calls or mate at different times of the year. They may also become so physically different from one another that they are unable to physically mate. Additionally, even if they successfully mate, their gametes (eggs and sperm) may not be compatible with one another. Compatible gametes can join together successfully to create a zygote (fertilized egg). Even if the gametes are compatible, they may not result in a viable embryo or healthy offspring. The offspring may also be sterile (as is the case with our mule example).
4. When reproductive barriers form between populations of organisms, this is called **reproductive isolation**. If the reproductive barriers are significant enough to prevent the populations from mating to create viable and fertile offspring, we would say that speciation has occurred and the populations now represent two different species.

**3. At what rate (speed or pace) does speciation occur?**

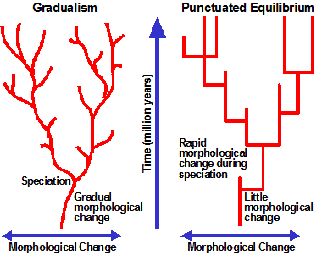
1. There are two models to describe the rate of speciation (i.e., the rate of formation of new species). Both have occurred at various points throughout the history of living organisms on Earth.
2. The model of **gradualism** states that evolutionary change happens at a slow, constant rate, which results in new species forming at a slow, constant rate. We see this occurring when there is a gradual change in environmental conditions.
3. The model of **punctuated equilibrium** states that there are periods of little or no evolutionary change followed by periods of rapid evolutionary change. This results in periods of time where very few, if any, new species form. These periods of time are often referred to as “**stasis**.” There are also periods where many new species form within very short periods of time. We see this occurring when there are periods of very little environmental change and periods of major, rapid environmental change. For example, the rapid cooling of the Earth’s surface may have resulted in the extinction of the dinosaurs and the rapid evolution of many mammalian species with adaptations to survive the cold (ex: fur).

***Practice Question #2:*** Look up the definitions of “punctuated” and “equilibrium.” How do these definitions relate to the model of punctuated equilibrium?

1. The models of gradualism and punctuated equilibrium are shown in the graphs given below. Time is shown on the x-axis, and the amount of evolutionary change is shown on the y-axis.



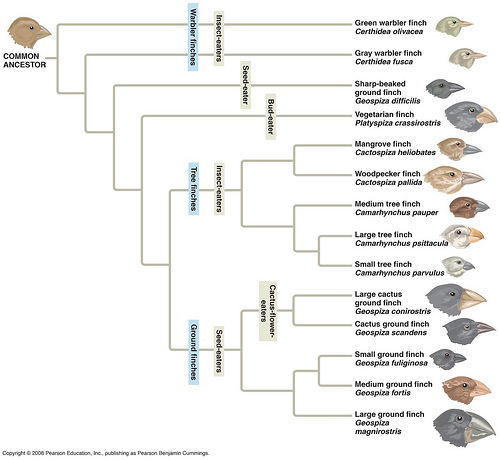
1. The **evolutionary trees** given below can also be used to show the models of gradualism and punctuated equilibrium. These evolutionary trees start with a single ancestor species at the bottom of the tree, and as time passes on the y-axis, species change as indicated by movement on the x-axis. New species are represented by branches off the main line. **Morphological change** means change in species’ physical structures.

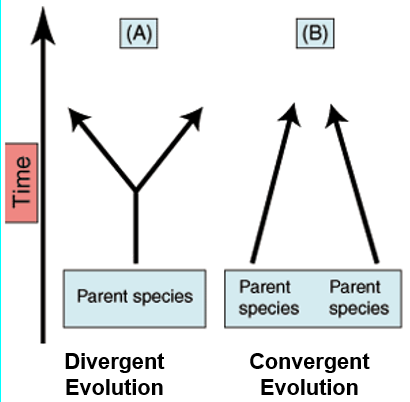


**4. What are some major patterns in evolution?**

1. We will learn about three major patterns in evolution—divergent evolution, convergent evolution, and coevolution. All of these processes take place over a VERY long period of time.
2. During **divergent evolution**, the exposure of members of a species to different environmental conditions results in this ancestral species branching/diverging into different species. When this happens very quickly and results in a large number of new species, this process is called adaptive radiation. In other words, **adaptive radiation** is an extreme form of divergent evolution.

For example, adaptive radiation occurred with Darwin’s finches when they quickly moved to the different Galapagos islands and encountered different food sources and other different environmental conditions. As a result, many new species of finches were formed over a short period of time.

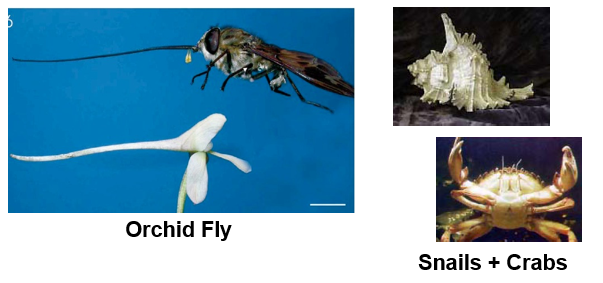




1. During **convergent evolution**, species that do not share a recent common ancestor become more similar over time due to similar environmental conditions. In other words, they converge or come together.

For example, convergent evolution occurred among dolphins and sharks, which gave them similar body shapes. They do not share a recent common ancestor. Dolphins are descended from a mammalian ancestor, whereas sharks are descended from a fish ancestor. However, both groups evolved similar body shapes to help them swim quickly in their aquatic environment.

1. During **coevolution**, different species that interact with each other evolve certain traits in response to one another.
2. For example, the orchid fly helps orchids to reproduce through pollination. The orchid, in return, provides nectar for the orchid fly. Over time, the orchid fly has evolved a long nose-like structure called a “proboscis” in response to the orchid evolving a deep container-like structure for nectar called a “receptacle.” As the orchid’s receptacle gets deeper, the fly’s proboscis gets longer and vice versa. This has resulted in the orchid and orchid fly having a very exclusive mutualistic relationship. Other insect pollinators do not typically pollinate orchids because they cannot get to the nectar.
3. Snails and crabs have also demonstrated coevolution, but this time, coevolution occurs through a predator/prey relationship. Crabs eat snails and have evolved large, strong claws to crack through the snail’s shell. In response, snails have evolved thicker shells to prevent the crabs from cracking their shells. In response to these thicker shells, crabs have evolved even larger, stronger claws (and so on and so forth).



***Practice Question #3:*** For each scenario described below, identify whether it is an example of divergent evolution, convergent evolution, or coevolution.. Explain your choice.

1. A species of fox evolves longer claws to dig for weasels as weasels evolve longer bodies to burrow deeper into the soil to escape the foxes.
2. Two populations of frogs of the same species evolve to mate at different times of the day. Eventually (due to lack of breeding between the populations), the populations become so different that they are considered two separate species.
3. Two species of insect that are not closely related become more similar over time because they both live inside trees